Mass Customization Quest

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ABSTRACT
As part of an ongoing research project, this Paper is intended to present some of the main questions emerged when preparing a series of experiments for the generation and arrangement of facade elements in mass customized dwellings.
In general, two differing approaches have been tried in panelization of regular and irregular facades in buildings. The first one is based on dimensional coordination strategies and is regarded as being the most efficient in terms of material usage and production rationalization. The other is derived from the more open strategy of deriving individual panel dimensions from a UV grid and its transformations.

KEYWORDS: Mass Customization; Parametric; Low-income Dwelling

Precedents

The experiments in this research depart from quite regular facade geometries, falling on the more traditional approach of dimensionally coordinated component design and deployment.

Whether it is possible to deploy mass customization techniques, i.e. CNC and Robotic Milling for production of highly customized building components and still keep low cost production in the Brazilian low-income housing – HIS – market is yet to be proven or disproven.

Four main options surface when considering mass customization for low-income: modular coordination of prefab components, machined form work for cast in place concrete construction and pre-fab machined non-standard components and last but not the least, mass production of full or partial housing units in industrial plants.

In-situ and pre-fab form-work strategies are economically feasible if form-work reuse is part of the equation. Once different forms are needed to complete a building, the reduced reuse of forms begins to pose a serious threat to economic feasibility.

Machined non-standard components might surface as the obvious choice, but highly dependent on the types of materials to be deployed in the construction process. For the most part, machined wood construction components seem to be the a feasible choice, but it entails careful re-use of wasted materials in the timber industry. Besides, fire regulations and other performance issues might preclude mass use of wooden components for other than low rise buildings. Cement and ceramic materials are not machineable to large pieces, needing instead CNC machined formwork for their production. And materials such as plastics, composites and the like are not economically sound in this scenario.

Industrial production of full or part sized housing units may still face a long delay before becoming feasible. It may be that such a "move away from tradition requires an industry wide initiative, just like Henry Ford led the way with mass production." (Gilles, H., 2008). Examples from Kullman Offsite, ModuleCo and others are probably the most complete, but the model demands a structured and highly sophisticated supply chain. In the present days, we can barely imagine having a regular supply of construction components to be delivered in situ.

Modular coordinated componentization seems to be the most feasible way for obtaining highly variable facades. Pre-fabricating a family set of panels which can then be combined into complex patterns has been a common strategy in the 20th Century. Assuming that product design can be tackled elsewhere, this project concentrated on the investigation of programmable architectural parameters associated to the building design phase.

Parts of this research were greatly inspired by the work of Boyer, 2006, trying to accomplish at least some parts of his own purpose, "efficiency of modular thinking without rote repetition".

Development

This HIS research project evolved around site planning issues, climate constraints and volumetric solutions for a mass dwelling building design system. The initial assumption, departing from regular geometries in building design towards more dynamically oriented blocks responding to site and climatic constraints has proved excessively complex.

Initial considerations indicated that, apart from solving plans for different family programs, the resulting building volumes should also result in *non-regular* urban landscapes.

Thus, the problem was broken down in smaller, discreet tasks.

Out of the many tasks in the project, four tasks were carried by teams comprised of a professor and a group of students. The most important point was to have the students to reveal one design parameter and to code it using Grasshopper.

Task 1 – Regular blocks alongside a guideline

In this task, the main focus was on how to distribute rather conventional apartment blocks in a different manner than the square grid.

Apartment blocks concatenation according to a guide spline. The spline might represent a topographic curve, a meandering river, a path way or road.

Sub-routines based on Ted nGai solar evaluators – Incident Solar Day and Incident Solar Year – were rewritten and deployed to indicate whether each façade would result over exposed to sun and, additionally, feed the panel/window selection routine. Ecotect was employed for numerical evaluation of some of the final models, which were exported to Revit for further development.

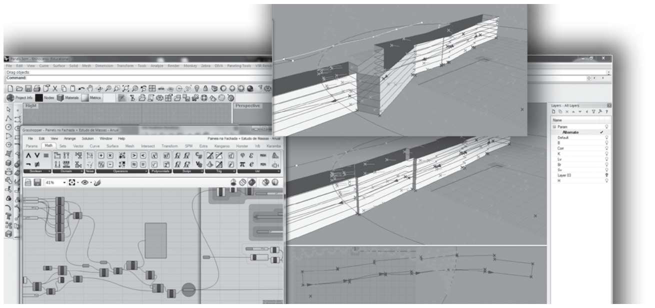

Figure 1 – Volumetric editing according to a spline guide.

Task 2

Alignment of individual flats to a guide spline. A variation of the first task, this time each individual apartment should be positioned relative to the guide line, in order to break the monotonous volumes even more.

A series of individual flats were pre-modeled and their volumes stored as blocks. A randomizing routine was devised to pick different flats and insert them serially.

Two criteria for positioning each flat were adopted:

Criteria A: midpoint on flat's facade should fall on the guiding spline;

Criteria B: If the flat façade resulted too recessed from the previous one, a correction should be applied pulling it up to 1.8 meters from the previous one. (this was though as a rule of thumb to avoid excessive shadowing or blocking landscape views from the flat).

Again, Ted nGai's solar routine was plugged to provide solar evaluation for each facade and feed the panel/window selection routines.

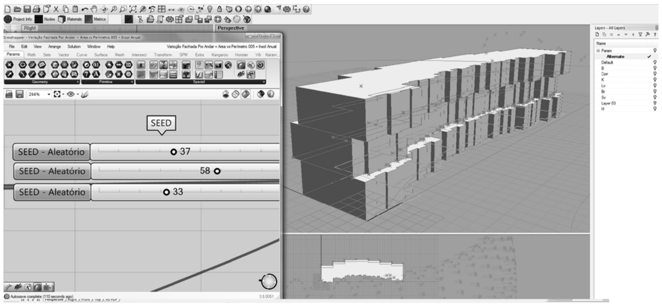

Figure 2 – Variation in Apartment positioning

Task 3 - Random positioning of panels on a facade

This task's purpose was to get random and semi-random distribution of facade panels. The full routine would comprise:

A. Identification of each part of the facade as pertaining to an individual flat;

B. Applying randomization to each flat's part of the façade;

C. Choice of type of panel and size of opening (window) for each panel.

The routine was not completed in that the part C. wouldn't run once integrated to the full code. Nevertheless, each part would run successfully when used separately.

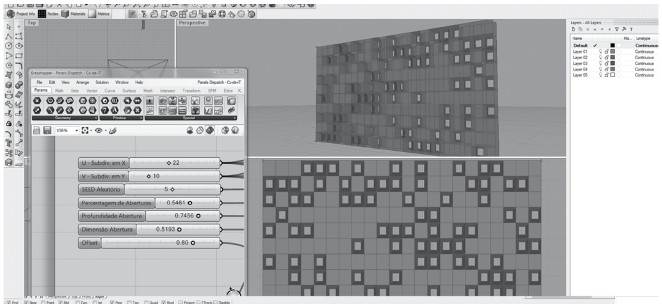

Figure 3 – Panel randomization: SEED 5; Percentage 0.5461

Task 4 - Choice of panel accordingly to solar exposition.

This routine was connected to data obtained from the rewritten Ted nGai solar incidence evaluation program for Grasshopper.

Other than randomizing the choice of panel, the solar routine reads the solar value for a given panel and chooses from a list of available options the right one for the situation.

We intended to have other constraints operating on this selection routine, such as choosing the type of panel according to the contiguous room; choosing the type of panel according to the exterior sound pressure, and others.

The team succeeded producing each checking routine but failed combining all of them into a logical sequence.

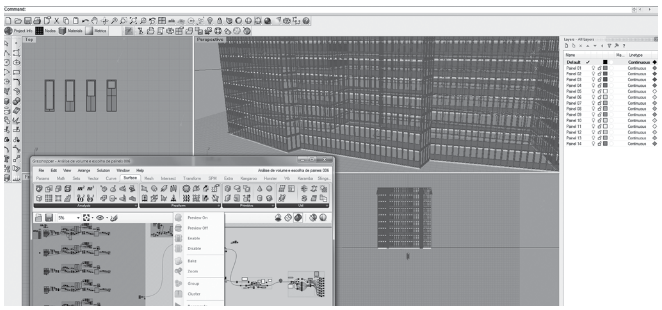

Figure 4 – Routine for selection of Panel/Window according to measured solar incidence.

Conclusions

The presented research is incomplete. The team is now working on a more structured analysis of parameters affecting Social Housing before making new attempts to program new subsystems.

In the current Brazilian HIS scenario, it seems that economical and political factors will be the most important issues to be addressed before further steps are taken towards the quest for good quality low income architecture.

As of today, initiatives are constrained by economic feasibility criteria as seen from major players – real state investors, building companies, architectural design studios and governmental agencies.

Quality wise, architectural thinking remains stalled in the old days' pursuit of standardized spaces and rationalized construction, a.k.a. *repetitive component production and assembly*. On the other hand, discourse towards mass customization has to be reshaped out of the present blunt figures, if it is to be of any use in harsh economic conditions and very low-income customers.

The main issue is and will continue to be an old one: how to measure *real state value* out of formal, spatial and functional qualities as perceived by users and architects.

Econometrics may still be the major player here, instead of *Parametrics.*

References

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Notes

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